NAVSEA
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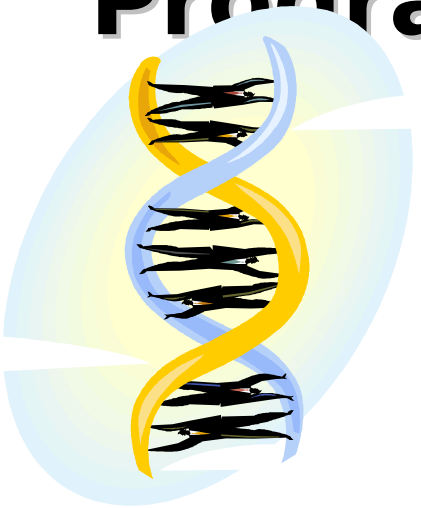
Surface Warfare Center Division

Integrated Detection of Hazardous Material Program



M. Todd Griffin
Chemical/Biological/Explosives Detection Team
NSWC, Crane Division

Distribution Statement A - Approved for public release; distribution unlimited.

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Talk Outline

- NSWC, Crane Descriptive Overview
- Chemical/Biological/Explosive Detection Team Overview
  - Current Products
  - Current Customers
- Integrated Detection of Hazardous Materials (IDHM) Program History and Overview
- IDHM Outgrowths
- Future Direction
  - Opportunities

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Second Largest Navy CONUS Base

Data as of 1/16/01

- **Total Land Area.....62,938 acres**
  - **Main Site.....62, 467 acres**
  - **Glendora Lake Facility.....461 acres**
  - **Fallbrook .....10 acres**
  - **Timberland.....48,583 acres**
  - **Perimeter Fence.....60 miles**
  - **Roads, Streets & Highways.....411 miles**
  - **Unpaved Roads.....226 miles**
  - **Railways.....163 miles**
- **Buildings & Structures.....2,634 (11.1 million sq. ft.)**
  - **Populated Buildings.....152 (2.4 million sq. ft.)**
  - **Storage.....(7.9 million sq. ft.)**
    - **Magazines.....1,705**
    - **Inert storage warehouses.....168**
- **Land Value.....$80.0 million**
- **Facility Value (Current Plant Value).....$1.5 billion**
- **Equipment Value (Acquisition Cost of Equipment)...$301.3 million**
  - **Main Site.....$ 295.2 million**
  - **Fallbrook..... $ 6.1 million**

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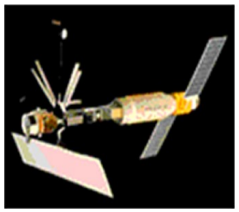
Engineering/Logistics

'Providing Tomorrow's Solutions'

Space-------Air-------Surface---Undersea

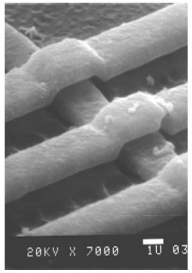


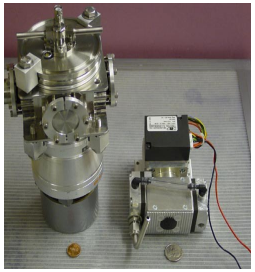
Commercial - Defense Technology Integration

Specialized Combat Systems and Subsystems

Platform System Engineering

Products and Components





Product Engineering

Displays | Microwave Tubes | Microelectronics | Batteries | NV/Chem/Bio/Explosives

Harnessing the Power of Technology for the Warfighter

Joint CBD Program Taxonomy

Dr. Dale Klein

Dr. Anna Johnson-Winegar

USD (A,T&L)

OSD NBC Defense Steering Committee

Oversight

Joint NBC Defense Board
(Exec. Agent: Army)

JSMG

JRO

Management

Army

Navy

USMC

USAF

DARPA

OJCS

JPO-BD

Execution

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Chem/Bio/Explosive Detection

FACILITIES

- Unique 25,000 Sq. Ft. Chemical/Biological Detection Center
- Physical Plant Replacement Value of $4.0M
- Specialized Chemical/Biological Detection Equipment with Replacement Value of $5.0M
  - Thermal Collimators
  - Chemical Vapor Diagnostic Test Sets
  - Chemical Vapor Generators
  - Chemical Hazard Containment Room

CAPABILITIES

- Develop & Review Specifications
- Develop Procurement Technical Data Packages
- Contract for Products, Components or Services
- Acceptance Test New Systems
- Repair Chemical Detection Devices
- Provide On-Site Fleet Support and Training
- Initiate & Implement Engineering Change Proposals
- Provide Sustainment Logistics Support for New & Existing Systems
- Perform Failure Analysis
- Hold Navy Radioactive Material Handling Permit

PERSONNEL

- Highly Technical Workforce of 51 Professionals with Extensive Chemical/Biological/Explosive Detection Experience
- Skills Mix of Thermal Imagers, and IMS Expertise
- 19 Engineers and Scientists
- 32 Skilled Technicians/Logisticians/

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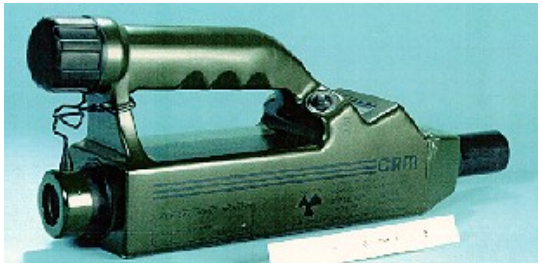
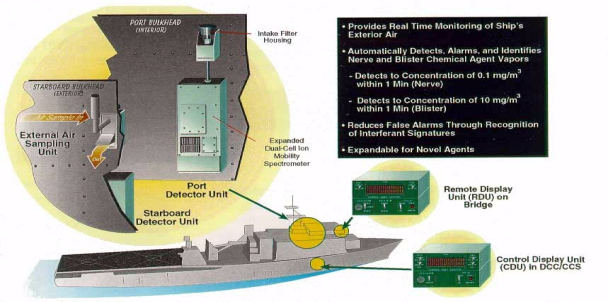
Products Fielded/Supported

utomatic Chemical Agen
etection Alarm (ACADA



nproved Chemical Agen
Monitor (ICAM)


PORT BULKHEAD (INTERIOR)
Intake Filter Housing
STARBOARD BULKHEAD (EXTERIOR)
External Air Sampling Unit
Expanded Dual-Cell Ion Mobility Spectrometer
Port Detector Unit
Starboard Detector Unit
Remote Display Unit (RDU) on Bridge
Control Display Unit (CDU) in DCC/CCS
• Provides Real Time Monitoring of Ship's Exterior Air
• Automatically Detects, Alarms, and Identifies Nerve and Blister Chemical Agent Vapors
- Detects to Concentration of 0.1 mg/m3 within 1 Min (Nerve)
- Detects to Concentration of 10 mg/m3 within 1 Min (Blister)
• Reduces False Alarms Through Recognition of Interferant Signatures
• Expandable for Novel Agents

nproved Point Detection Sy
(IPDS)

Shipboard ACADA

porTracer II (Explosive

AN/KAS-1/1A

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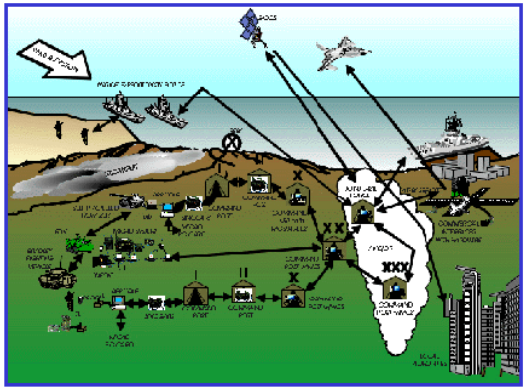
Joint Program Products

t Warning and Reporting Netw
JWARN

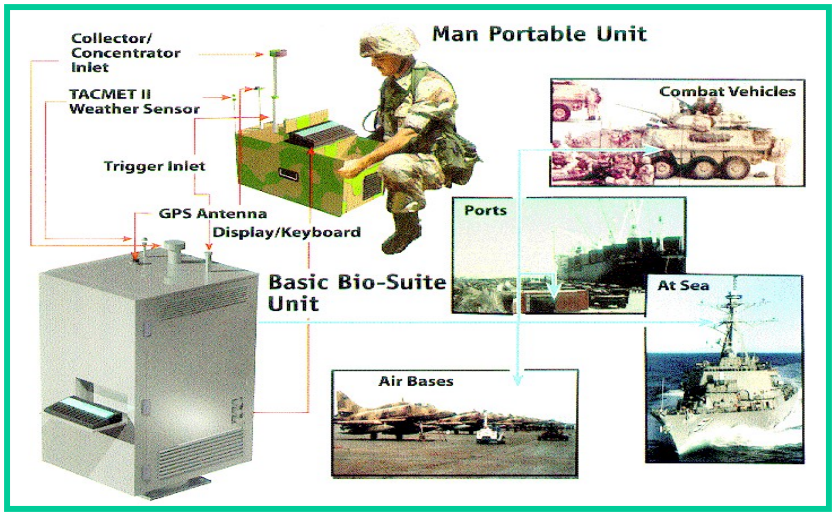


nt Chemical Agent Detect
JCAD

Lead Service
• Automatically detect, identify and quantify chemical agents
• Lightweight and portable
• Interfaces with JWARN
Preconcentrator
• Allows JCAD to Meet Low Level Detection Limits
Pulsed Air Sampler
• Allows JCAD to be used as a Survey Instrument
Detector Unit
ON
SEL
Universal Mount
• Meets 40G Shock and Crash Safety
• Used for All Mounting Requirements
Man Portable

Joint Standoff Detector
JSLSCAD

Lead Service
• Provides on-the-move, automatic standoff chemical agent detection
• Mounts on Service platform(s)
• Detects and alarms to a chemical agent vapor cloud up to 5 Km in range
• Replaces M21 RSCAAL
Interferometer
Scanner
Agent Cloud
5 Km
Display Unit



Joint Biological Point Detection System JBPDS

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Code 805D Customers

- Navy
  - Naval Sea Systems Command
  - Naval Special Warfare Command
  - Navy Inventory Control Point, Mechanicsburg
  - Navy Explosive Ordnance Disposal Units
  - Navy Construction Battalions
  - Office of Naval Research
- Other
  - Defense Threat Reduction Agency
  - Soldier, Biological, Chemical Command
  - Joint Program Office – Biological Defense

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Code 805D Tasking

- Acquisition Engineering Support
- Production Acceptance Testing
- Installation & Fielding Support
- In-Service Engineering Support
  - Product Improvement Programs
  - Configuration Management - Hardware and Software
  - Intensified Leak Test Tracking for Radioactive Sources
- Depot Maintenance and Repair
- Support New Construction Ships
- Product Integration (System Design and Integration)

Integrated Detection of Hazardous Materials

- Crane – Contract Administration, Technical Coordination, and Liaison Activity
  - Project Management
  - Systems Engineering / Integration
- Purdue – Contractor
  - Assigned PIs for basic and applied research tasking
- Dahlgren – Technical Oversight
  - Test and Evaluation

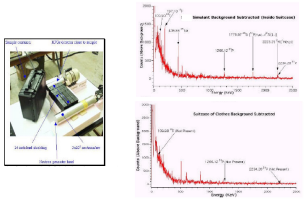
Harnessing the Power of Technology for the Warfighter

Integrated Detection of Hazardous Materials

3 5 7 10 Product Time Line (years)

Gamma Ray Spectroscopy

David Koltick, Purdue University Physics



Miniature Cylindrical Ion Trap Mass Spectrometer

R. Graham Cooks, Department of Chemistry, Purdue University

Selective Sampling: MIMS

Miniature Mass Analyzers

Semi-volatile Analysis with MIMS

- ultra-thin (0.5 μm) membranes
- trap and release methods
- desorption MIMS (thermal)
- cryotrap MIMS
- Laser desorption MIMS

Single-Sided Membrane Introduction

12 ppb dimethyl methylphosphonate (DMMP) in air,
1 sec exposure to the silicone membrane

V = open to vacuum
R = thermal release analyte from membrane (300° C)

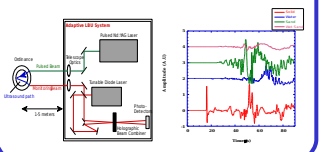
Advanced Signal Processing

Rong Gao, Lefteri H. Tsoukalas, Purdue University

Wavelet Filtering
Fuzzy - NeuroNets
Sensonets
Expert Control Systems

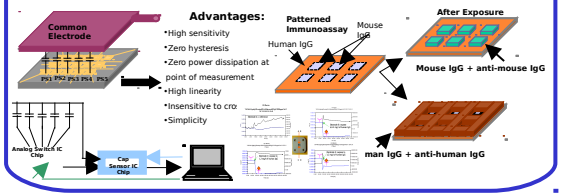
Laser Based Ultrasound

David Nolte, Physics Dept., Purdue University



Capacitive Based Micro-Bio Sensor

Fred Regnier and Dorota Inerowicz, Ron Reifenberger and Steve Howell, Purdue University

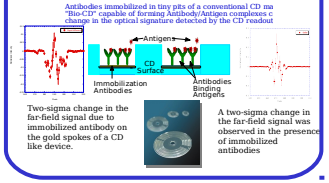


Bio-CD

David Nolte
Purdue, University

Billions of Pits=Billions of test tubes

Antibodies immobilized in tiny pits of a conventional CD ma
"Bio-CD" capable of forming Antibody/Antigen complexes c
change in the optical signature detected by the CD readout



Two-sigma change in the far-field signal due to immobilized antibody on the gold spokes of a CD like device.

A two-sigma change in the far-field signal was observed in the presence of immobilized antibodies

Ion Trap Mass Spectrometry for Biological Agent Detection

Scott A. McLuckey,
Chemistry Department Purdue University

Goal:

Rapid detection and identification of toxins, viruses, bacteria

Strategy:

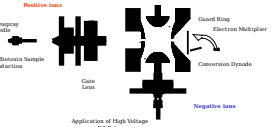
biomarkers:	proteins
ionization:	electrospray
chemistry:	dissociation of high mass ions and ion/ion reactions for ion charge state manipulation using MS- techniques
analysis: identification:	quadrupole ion trap mass spectrometer matching to protein database

Performance Goals:

ID time:	seconds to minutes
Detection levels:	low fmol (1-10 ACPLA)
Range of targets:	peptides/proteins

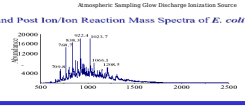
Ion/Ion Trap Instrument Schematic

Quadrupole Ion Trap Mass Analyzer

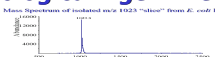


Hitachi M8000 Ion/Ion Instrument Photos

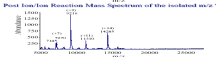
Pre and Post Ion/Ion Reaction Mass Spectra of *E. coli* Fraction #6



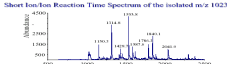
Mass Spectrum of isolated m/z 1023 "slice" from *E. coli* Fraction #6



Post Ion/Ion Reaction Mass Spectrum of the isolated m/z "slice"

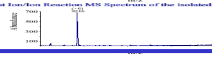


Short Ion/Ion Reaction Time Spectrum of the isolated m/z 1023 "slice"



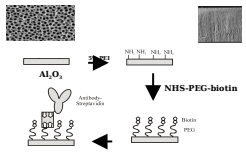
Mass Spectrum of isolated m/z 1333.8 from the Short Ion/Ion Reaction

Post Ion/Ion Reaction MS Spectrum of the isolated m/z 1333.8 Ion



Nanoporous Membrane Separation Methodologies

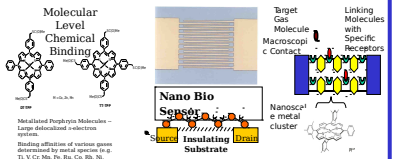
Gil Lee, Purdue University



• The surface of the membrane has been modified with a hydrophilic polyethylene glycol (PEG) monolayer.

Chem/Bio Nano Sensors

David B. Janes, Ron Andres, Purdue University



Metallated Porphyrin Molecules – Large delocalized π-electron systems

Binding affinities of various gases determined by metal species (e.g. Ti, V, Cr, Mn, Fe, Ru, Co, Rh, Ni, Pd, Cu, Ag, Zn, Cd, Hg).

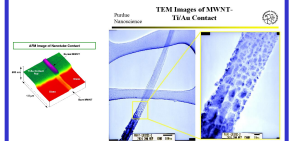
Common caged structure allows development of generic platform for sensing various species.

THz TDS for Biological Agent Detection

Stephen Durbin & Andrew Weiner
Purdue University

Carbon Tube Resonator

Ron Reifenberger & Albert Chang
Physics Dept. Purdue University

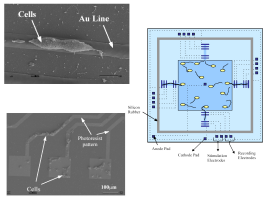


Here we show a TEM image of the transition from the unmasked section of the MWNT (lower) to the masked section (upper). The horizontal objects are the support structure on the TEM grid.

A higher magnification image shows the interface between the Ti/Au and the MWNT. This data supports the theory for ohmic contact in determining the conductance of the materials.

Brain-on-a-chip

Rashid Bashir, Purdue University



Introduction

The Integrated Detection of Hazardous Materials (IDHM) program is a multidisciplinary effort that brings top academic, government, and industry scientists and engineers together for the advancement of sensor development and integration. The IDHM program began with a congressional add that was used as a technology incubator. As technologies mature and develop, the projects are transitioned to alternate funding sources such as: DoE, NIH, ONR, and other DoD facilities. New technologies have been added with subsequent congressional money. Currently, there are nine tasks within the project. Naval Surface Warfare Center, Crane Division (NSWC Crane) manages and coordinates the project. Purdue University has established the Center for Sensing Science and Technology (CSST) to execute the IDHM research. The CSST has members from many departments across campus including: Chemistry, Physics, Biology, ECE, Mechanical, Chemical and Nuclear Engineering. In addition to coordination and working on basic research, NSWC Crane is also involved in the transition of technologies to fielded products through advanced concept design and packaging. Other DoD and DoE labs involved include: NSWC Dahlgren, Oak Ridge National Labs, Naval Research Lab, and the Army's SBCCOM.

IDHM Tasks

Of particular interest to the IDHM program is the rapid, sensitive, and selective detection of biological materials. To achieve selective detection with high reliability, the IDHM program addresses areas such as: complex environmental sampling and preparation, sensor development, signal processing, and database management. Currently, the IDHM program is conducting research in the following areas:

- Cylindrical Ion Trap Mass Spectrometry
- Advanced Ion Trap Mass Spectrometry for Biologicals
- Laser Based Ultrasound
- Bio-CD
- Neutron Based Detection
- Capacitance Based Micro Sensors
- Nanoporous Membrane Methodologies
- Brain-on-a-chip
- Carbon Nano-Tube Resonator
- THz TDS for Biologicals
- Chem/Bio Nanosensors
- Advanced Signal Processing and Data Management

Advanced Applications

NSCW, Crane leads the applications development effort for the IDHM program. As the DoD's representative, NSWC, Crane ensures that each project is meeting or exceeding current or future mission requirements. Through Purdue University's Research Park, two companies have been formed to help commercialize IDHM technological commodities. NSWC, Crane works with both companies to leverage shared product development. NSWC, Crane also evaluates military platforms that might benefit from IDHM technology. Using a parallel development approach and modular designs, NSWC, Crane is currently investigating advanced concept packaging for platforms that range from unmanned aerial vehicle (UAV) to a water monitoring system.

Future Directions

- Enhanced Techniques for Explosive Detection
  - Unexploded ordnance (UXO) detection and ID
  - Detection of improvised explosive devices (IED)
  - Trace detection for explosive ordnance disposal (EOD)
  - New Fieldable Explosive Sensors
- *in vivo* sensors
  - Bio MEMS
  - Nano Sensors
- Proteomics consortium

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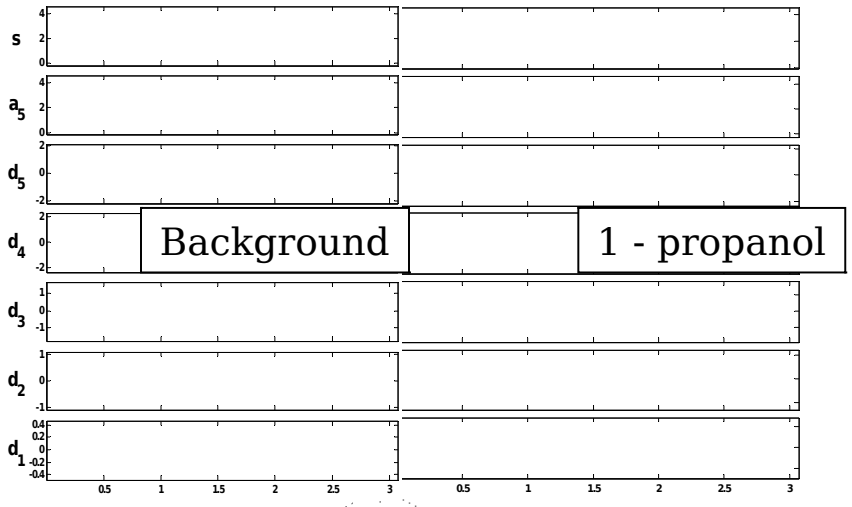
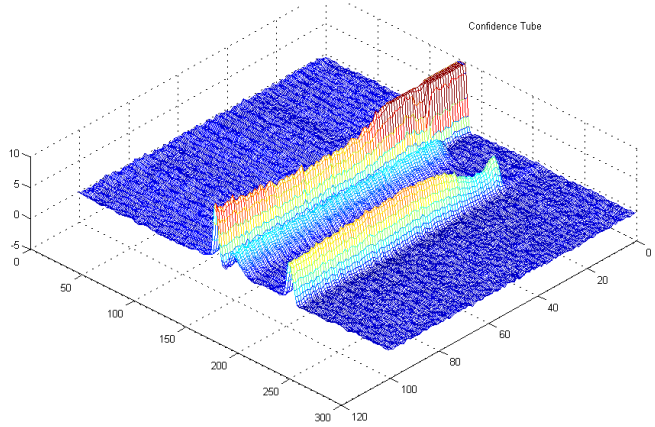
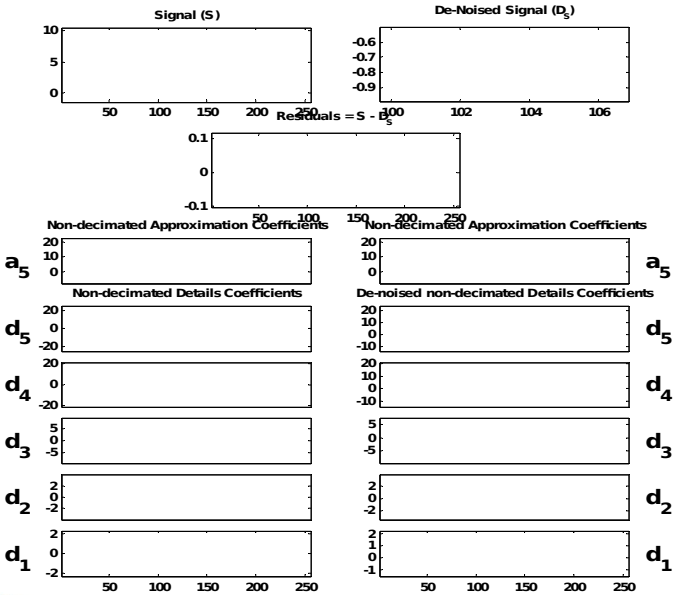
Improved IMS Systems

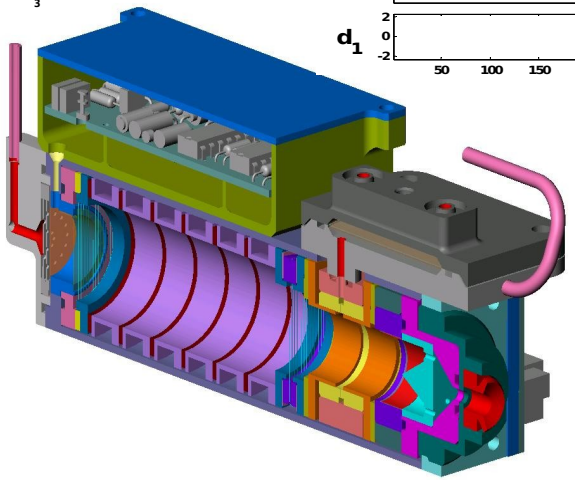
Increased Selectivity





10x Improved Sensit

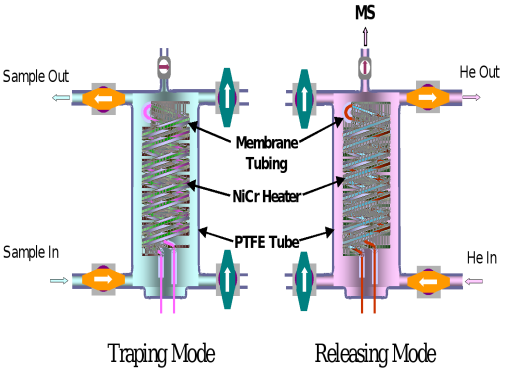


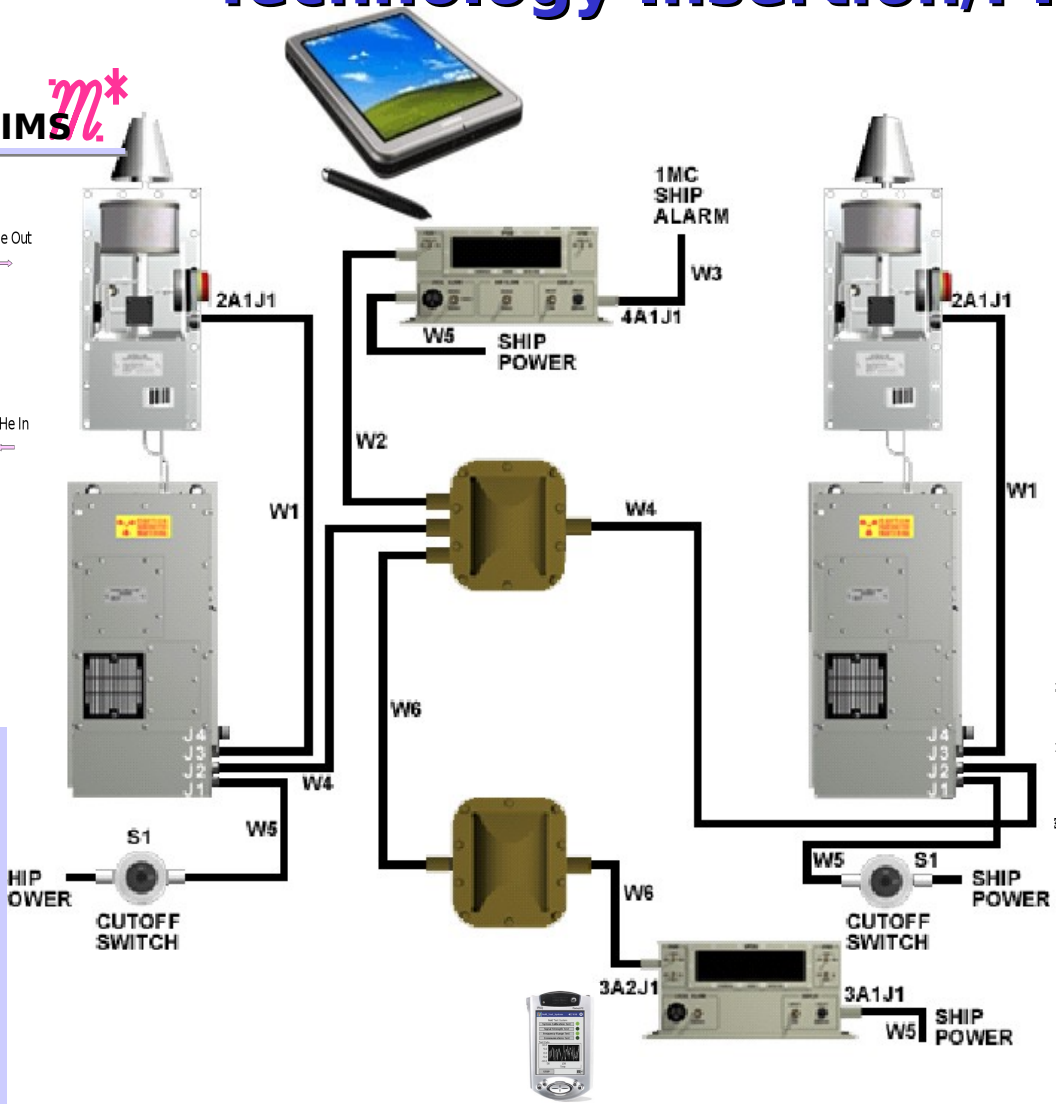


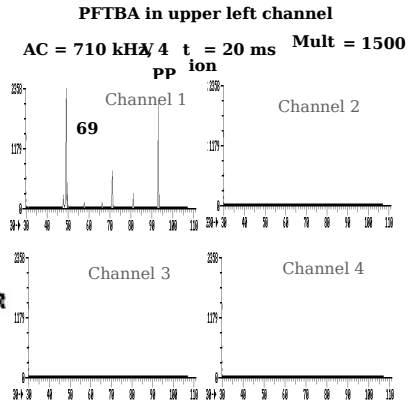
Harnessing the Power of Technology for the Warfighter

Improved (Chemical) Point Detection System Technology Insertion/PIP

Selective Sampling: MIMS

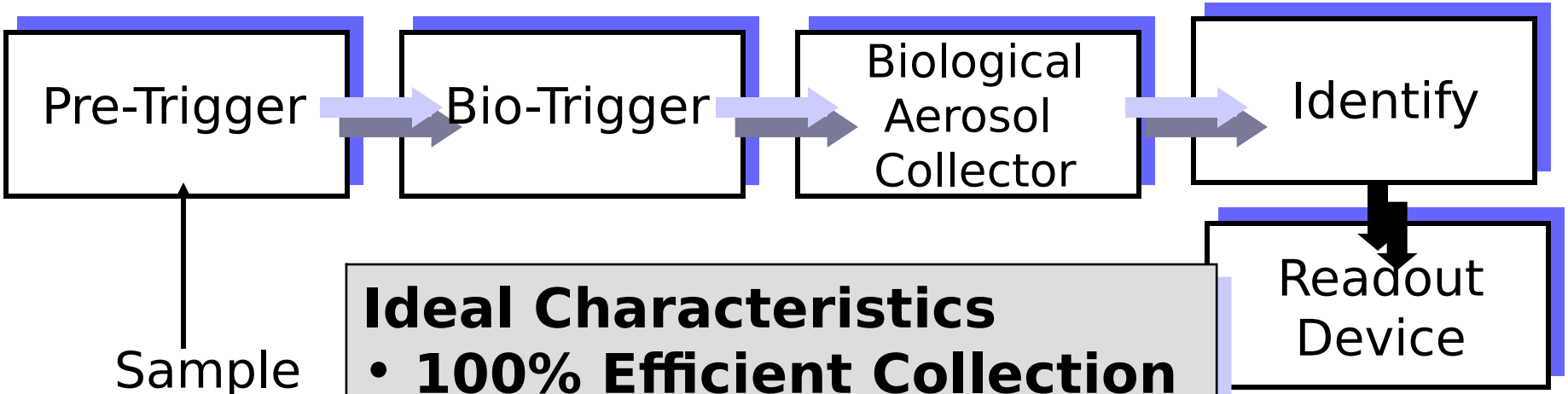






Harnessing the Power of Technology for the Warfighter

Biological Point Detection Concept



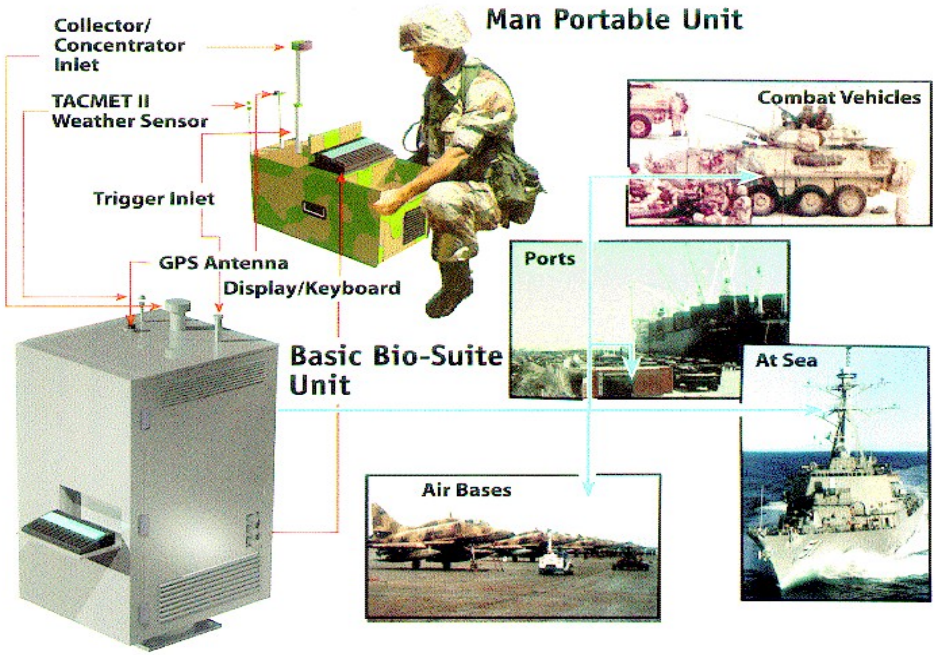
Ideal Characteristics

- **100% Efficient Collection**
- **Fast (Trigger and ID)**
- **Sensitive**
- **Selective**
- **No False Alarms**
- **Broadband Identification**
- **Universal Communication**

Joint Biological Point Detection Syste

Particle Size → Molecular Fluorescence → Wetted Wall Cyclone → Immuno-Assay Strips → Readout Device

Sample



Harnessing the Power of Technology for the Warfighter

Handheld Capacitance Based Bio Sensor Concept

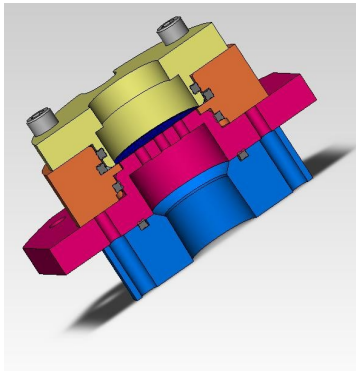
Electrostaticly Assisted Nanopourous Collector

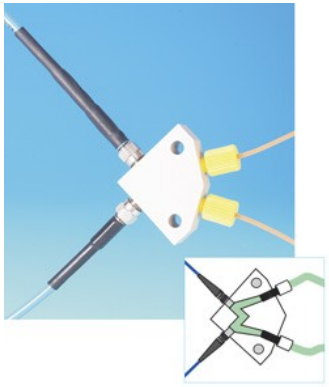
Sample

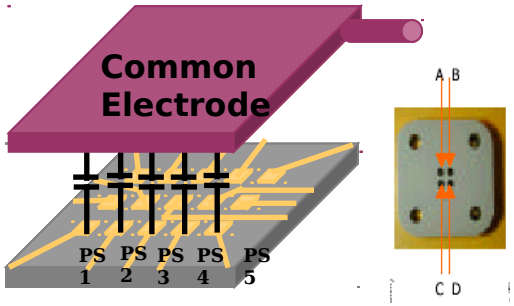
FIA Fluorescence

Cap-Bio Sensor

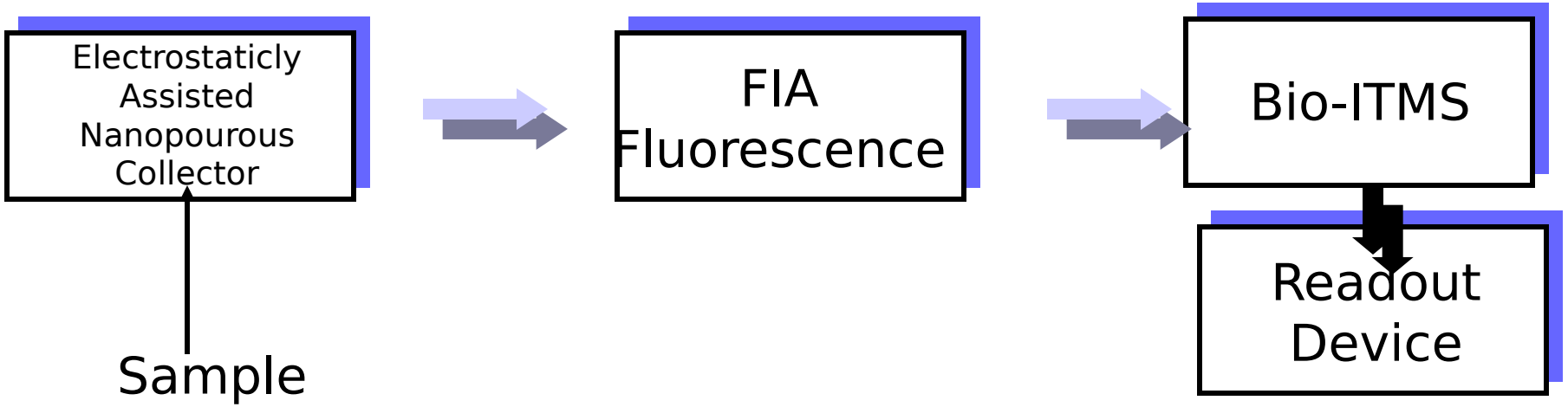
Readout Device

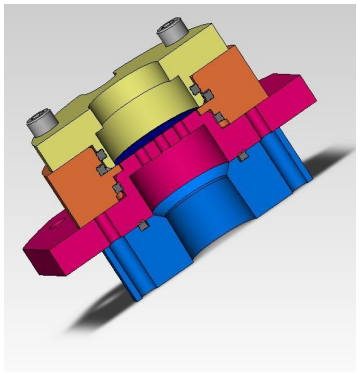


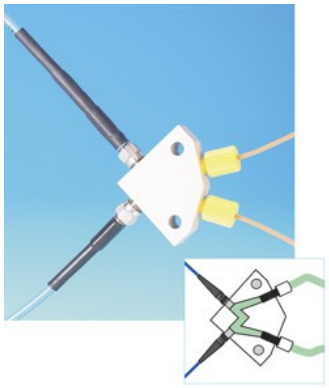


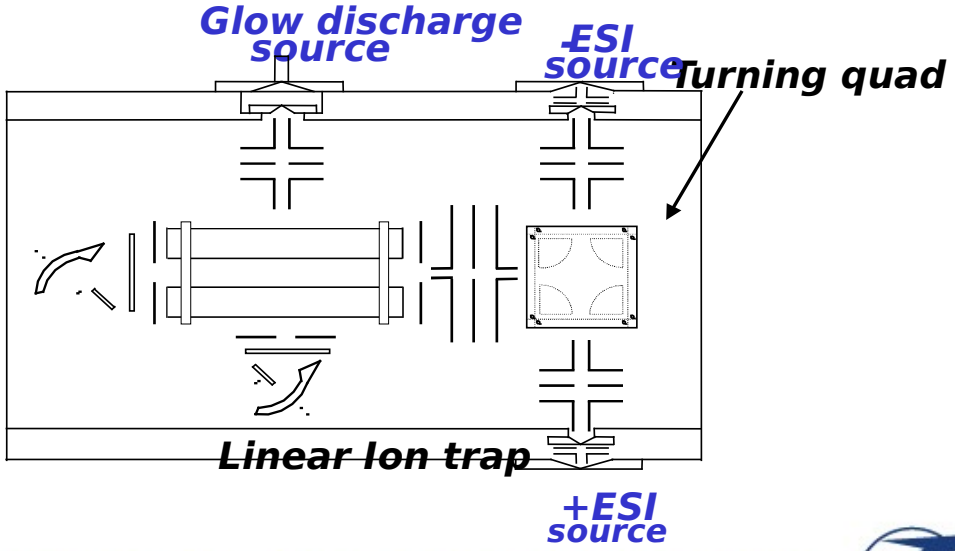


Biological Mass Spectrometer Concep









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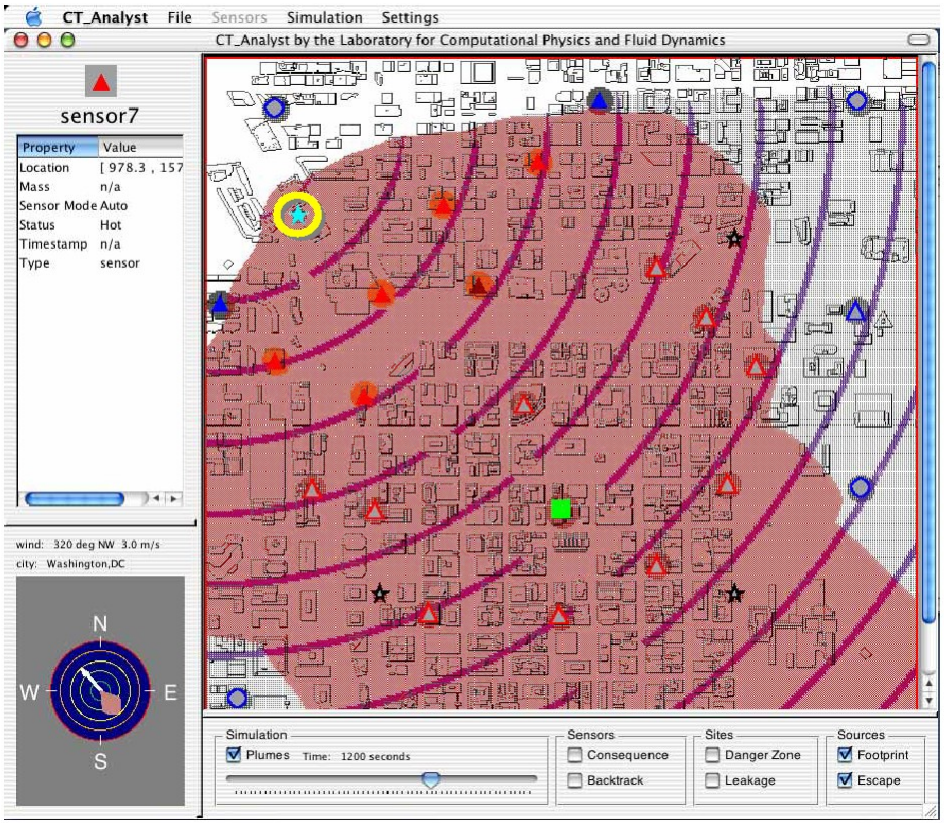
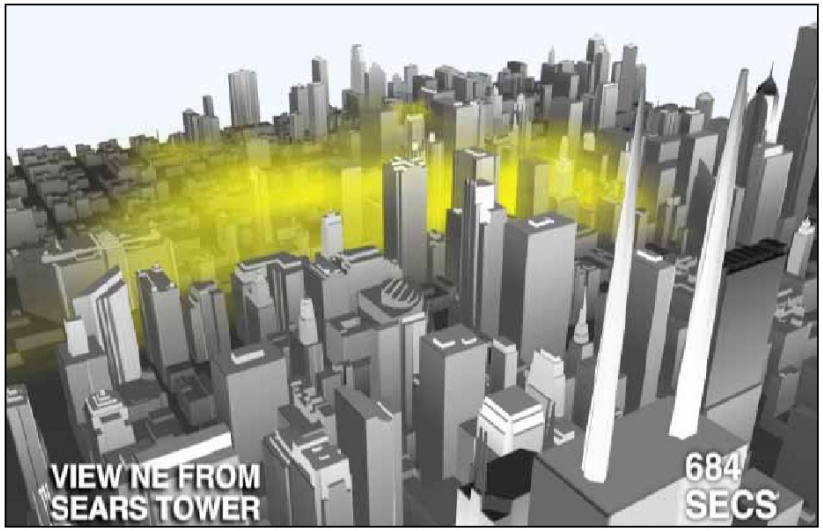
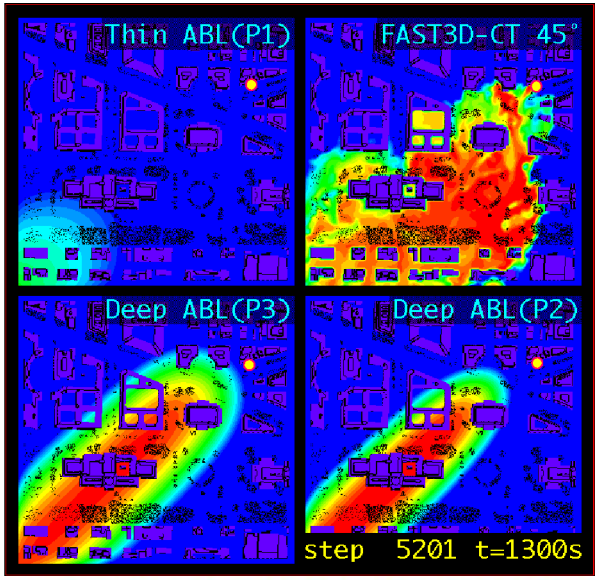
Fast and Accurate CBR Emergency Assessm







Harnessing the Power of Technology for the Warfighter

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Future Directions

- Integrated Contamination Avoidance Sensornet (InCAS)
  - Intelligent Sensornet – (Chem/Bio/Rad/Explosives)
  - NRL, Purdue University, NSWC, Crane
  - Sponsor interest in FY04 Demonstration
- Explosives Detection – *Leverage Existing Projects*
  - Next Generation Vapor Detectors
  - Standoff Detection
- *in vivo* sensors – *Planning Underway*
  - Bio MEMS
  - Nano Sensors
- Proteomics consortium –*Leverage Existing Programs*
- ATD & ACTD – *Joint Planning Underway*
- Technology Transfer – *Pursuing CRADAs*